Oct. 26, 1971 MAMORU SHINOZAKI 3,614,868

METHOD FOR STABILIZING AN EXCAVATED TRENCH BY STABILIZATION OF ASBESTOS SUSPENSION

Filed July 16, 1969

3 Sheets-Sheet 1

Fig. 1

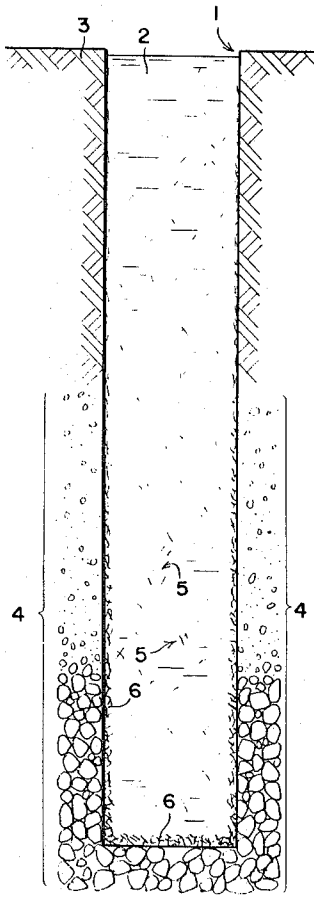
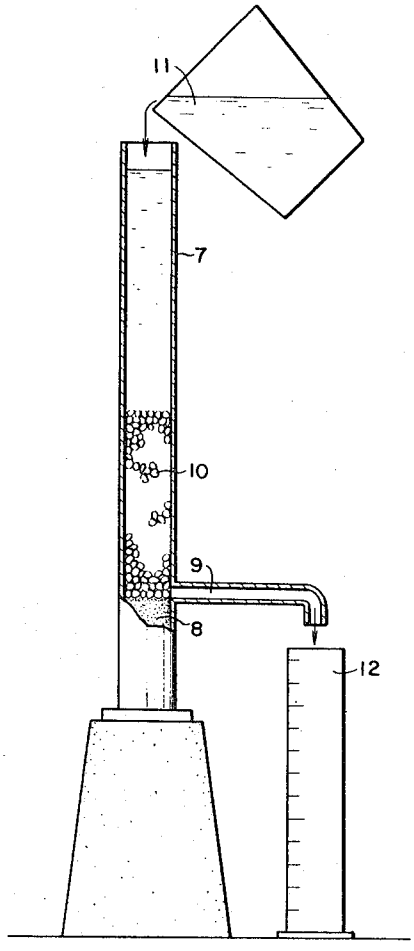


Fig. 2



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Fig. 3 A

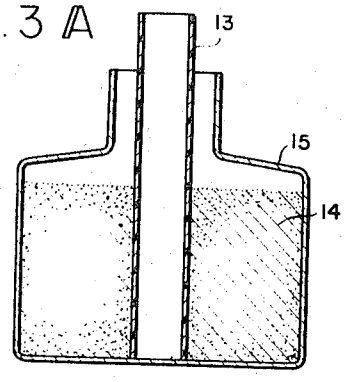


Fig. 3 B

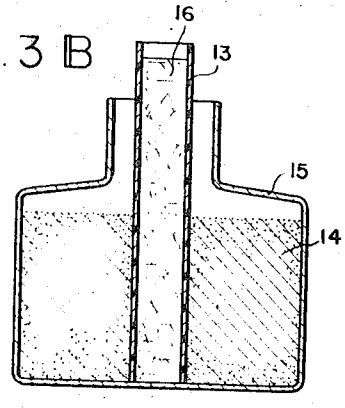


Fig. 3 C

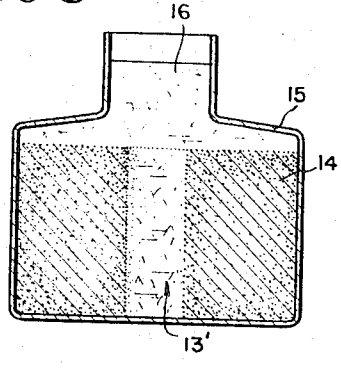


Fig. 4 A

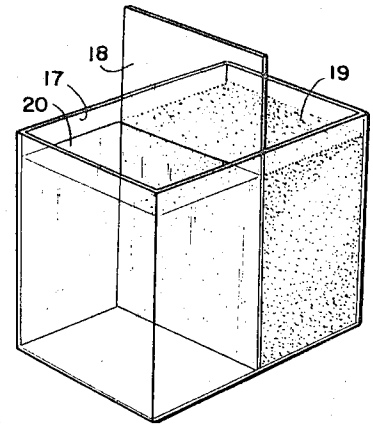
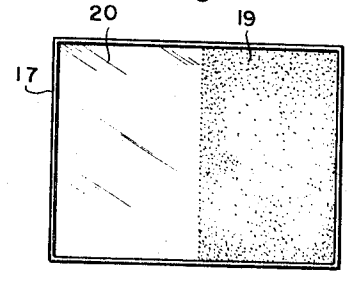
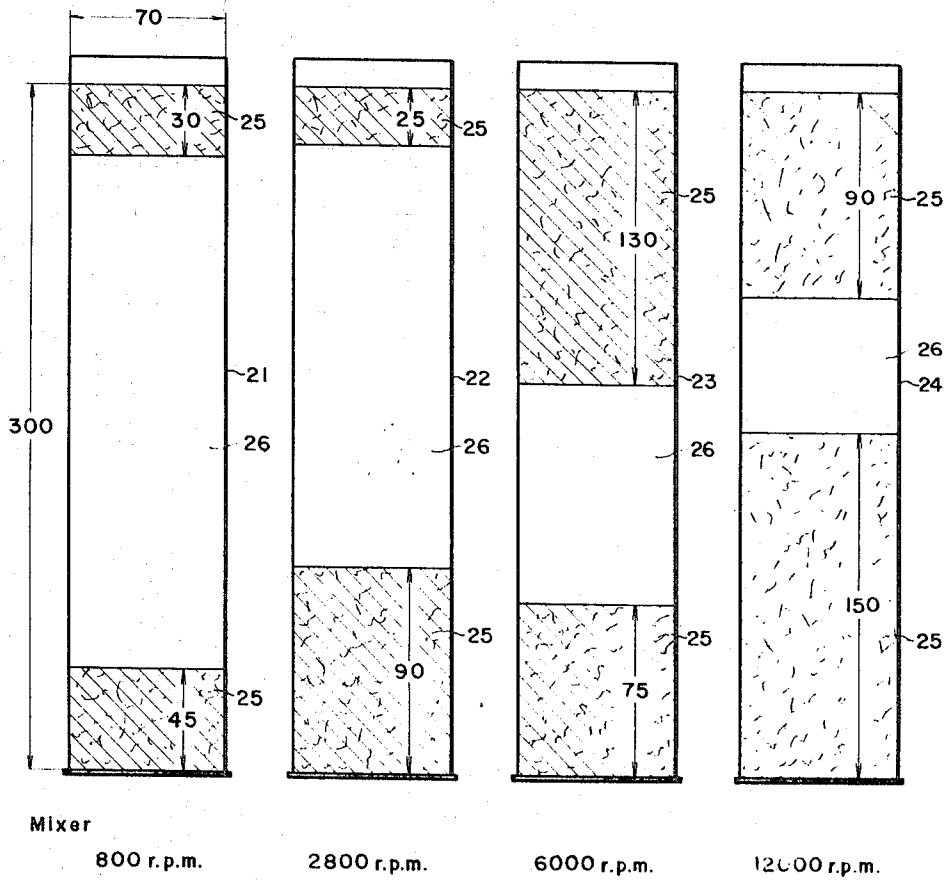


Fig. 4 B



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Fig. 5 A Fig. 5 B Fig. 5 C Fig. 5 D



United States Patent Office

3,614,868

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3,614,868

METHOD FOR STABILIZING AN EXCAVATED TRENCH BY STABILIZATION OF ASBESTOS SUSPENSION

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Claims priority, application Japan, July 17, 1968, 43/50,784
Int. Cl. E02d 17/08
U.S. Cl. 61—35 2 Claims

ABSTRACT OF THE DISCLOSURE

A method for stabilizing an excavated trench by filling the trench with a liquid slurry containing asbestos fibers in suspension with water. As the liquid slurry flows through the permeable walls of the trench the asbestos fibers will tend to seal the walls of the trench. The method further contemplates the use of the asbestos suspension along with a suspension of clay.

This invention relates to an improvement of the so-called slurry-trench method of earth-wall construction work in which there is utilized a slurry stabilizer containing clay, and more particularly to a development of a novel method of construction work capable of providing effects which have never been accomplished with the conventional bentonite slurry method.

In the conventional bentonite slurry method filled with bentonite suspension, the filled slurry has exhibited severe leakage when the method has been carried out in, for example, a place with gravel layer. It has been accordingly required to continuously supplement the stabilization by providing additional clay suspensions.

Further, bentonite contained in the bentonite solution becomes gelled with calcium (Ca) ions of concrete, resulting in the formation of gelled films which cover the connected parts of concrete placing units. This has, in case of constructing, for example, a continuous earth-wall, provided enfeebled integration thereof.

Furthermore, when a vertical trench or bore hole for cast-in-situ pile has had a place of particularly heavy leakage at a certain depth from the surface of the earth, the clay slurry method of construction work by using the bentonite suspension has been incapable of locally increasing the concentration of bentonite in the filled slurry at a particular depth. More particularly, the slurry used which has contained bentonite has been uniform in concentration; and for this reason, in the excavation of such a ground as above-mentioned, the whole stabilizer used must be high in the concentration of bentonite and hence a large amount of bentonite must be used which will increase the cost of construction.

Accordingly, a primary object of the present invention is the formation of a facing or a water cut-off wall capable of preventing leakage in an extremely simplified and easy manner.

Another object of the invention is to improve the quality of the surface of concrete placed in a trench or bore hole, thereby improving the binding property of the concrete.

Still another object of the invention is to locally increase the concentration of asbestos in a clay slurry and thus to prevent local leakage in an excavated trench, thereby saving the amount of asbestos used and hence cutting down the cost of construction.

Therefore, the characteristics of the invention to achieve the above and other objects may be listed as below:

A method for stabilizing an excavated trench characterized by filling said excavated trench with stabilization of suspension containing asbestos and water, so that a water cut-off property is imparted to said trench to form stable trench walls;

The method according to the above where said excavated trench is filled with stabilization of asbestos suspension added to a clay suspension;

A method for stabilizing an excavated trench characterized by filling said excavated trench with stabilization of asbestos suspension containing a surface active agent, and selecting the number of rotation per minute of a mixer agitated therewith, so that a greater concentration of said asbestos suspension may be placed at a specific depth to obtain a good water cut-off property;

A method for stabilizing an excavated trench characterized by filling said excavated trench with stabilization of asbestos suspension containing a surface active agent and granular particles, and selecting the number of rotation per minute of a mixer agitated therewith, so that the density of said asbestos suspension is made higher to obtain a good water cut-off property and stabilizing effect.

The method of construction work according to the invention will now be described in detail along with the explanation of the accompanying drawings and various experiments.

FIG. 1 shows a longitudinal section of a trench for constructing an earth-wall, the trench being filled with a stabilization of asbestos suspension in accordance with the method of the present invention;

FIG. 2 shows a diagram for explaining experiments having been made to compare the water cut-off effect of the bentonite slurry having been hitherto used for the stabilization of suspension and that of a clay slurry consisting of a bentonite suspension diffused and incorporated with fibrous asbestos according to the present invention;

FIGS. 3A, 3B and 3C illustrate explanatory diagrams of an experiment having been made to observe the water cut-off effect when there was used a stabilizer prepared by diffusing and suspending fibrous asbestos into water without using any bentonite at all according to the present invention;

FIGS. 4A and 4B illustrate diagrams concerning experiments wherein there were prepared a stabilizer containing asbestos and a stabilizer containing bentonite in different proportions to observe the soil retaining effect of said two stabilizations; and

FIGS. 5A, 5B, 5C and 5D show diagrams for explaining experiments wherein a liquid stabilizer was prepared by adding asbestos and a surface active agent to water and was agitated by means of a mixer with varied revolution per minute thereof, thus to observe the formation of a particular region high in the concentration of asbestos at various depths below the liquid surface.

Referring now to the drawings, description of the present invention will be made hereunder in further detail.

In FIG. 1, the reference numeral **1** designates an excavated trench or bore hole for cast-in-situ pile for constructing an earth-wall (hereinafter referred to as an excavated trench), **2** designates a suspension incorporated with bentonite and asbestos and filled in the trench to retain the earth-wall, **3** designates soil, **4** designates a gravel layer accumulated under the soil **3**, **5** designates flocculant asbestos in the suspension **2**, and **6** designates thin films of asbestos adhered to the walls of the excavated trench.

Experiments have shown that the bentonite suspension containing water with bentonite and employed in the conventional clay slurry trench method of earth-wall construction work, when filled in the trench **1** for the construction of an earth-wall penetrates through, for example,

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gravel **4** at a deep part thereof, thereby permitting severe leakage through the gravel.

When the bentonite suspension is mixed with flocculent asbestos **5** of fine-diameter fiber, the asbestos will be diffused in the bentonite suspension and become suspended in water. When the slurry thus prepared is filled in the trench **1** for the earth-wall construction, the asbestos **5** suspended in the suspension **2** will be, following leakage, attracted towards the leakage voids of gravel **4** thereby attaching to the voids to gradually increase thickness of the asbestos film formed and to finally plug the leakage voids thereby stopping the leakage.

In other words, at the part of the earth-wall where there is a gravel layer **4** accompanied with leakage, the asbestos in suspension forms a thin film **6** by which the leakage is stopped.

The inventors have made the following experiments to confirm the above-mentioned results:

EXPERIMENT 1

As shown in FIG. 2, an acryl resin cylinder **7** having a length of 1,000 mm. and a diameter of 85 mm. was vertically placed and installed on a pedestal. The cylinder **7** was filled with fine sand **8** up to an outflow port **9**. On the sand grains **8** were placed gravel layer **10** ranging in diameter from 10 mm. to 25 mm., so as to amount to 330 mm. in terms of depth.

Into the cylinder **7** thus inserted with the sand grains and the gravels, there was poured 7.5 l. of bentonite slurry **11** made with 4% (by weight on the basis of water) of bentonite. It was noted that all the bentonite slurry **11** was drained through the drainpipe **9** of the cylinder **7** to a graduated vessel **12** in 90 seconds.

On the other hand, about 20 g. of flocculent asbestos was incorporated into 7.5 l. of the bentonite-containing slurry **11**. This was poured onto the upper surface of the gravel layer **10**. It was noted that only about 5 l. of the liquid was discharged in about 160 seconds, with approximately 2.5 l. being prevented from flowing out and was not drained.

The last-mentioned stabilization of suspensions, when added with a suitable paste material (for example, carboxy methyl cellulose i.e. C.M.C.), accomplished a more excellent water cut-off effect.

The difference in the water cut-off property between the two liquid stabilizers is considered to come from the fact that bentonite is in the form of minute particles, while asbestos is in the form of flocculent and fine-diameter fibers which are long enough to plug the voids of the gravel layer **10**. Furthermore, the fibers are as fine as 180 A. or so in diameter, so that they can provide precise plugging to plug the voids of the gravel **10**.

The asbestos used in the method of construction work of the invention is not necessarily, required to be of large length fibers but the asbestos may be of small lengths.

The slurry using bentonite is presently used at the concentration of 6 to 12% for the bentonite. On the other hand, the asbestos suspended slurry is satisfactory with about 1% of asbestos concentration. Thus, the amount of asbestos used may be far less than that of bentonite, and comparison between the two methods of stabilization of trench excavation revealed that the method using asbestos can lower the expenses.

In addition, the asbestos suspended in the slurry can be recovered, if necessary, by scooping it with a net or the like and then subjecting it to compression thereby easily separating it from water.

When an excavated trench is used with concrete, the slurry undergoes the phenomenon of gelation with the concrete and covers the connected parts of concrete placing units with thin films gelled. For this reason, when a continuous earth-wall is constructed, the integration of concrete is made feeble. In order to eliminate this disadvantage, the slurry need be added thereto with an additional agent such as humic acid soda to prevent said gelation.

In contrast, the slurry mixed with asbestos can easily and cleanly eliminate soils other than concrete from the connected ends of the concrete thereby to improve the binding property of the concrete, since the asbestos sticked to the cement wall is chemically bonded with cement extremely thoroughly.

Next, the experiment wherein asbestos was diffused and suspended into water without incorporating any bentonite at all, was as follows:

EXPERIMENT 2

First, into 300 cc. of water there were incorporated as asbestos those of 5R and 7M in accordance with the table of Standard Gradings In Quebec, Canada, in equal amounts. Furthermore, 7.5 g. of the aforementioned carboxy methyl cellulose, C.M.C., was added. The solution was then mixed witha mixer to prepare a slurry.

Separately, as shown in FIG. 3A, a cylindrical vinyl pipe **13** having a diameter of 100 mm. and being open at both ends was vertically buried by 300 mm. in a large glass vessel **15** which has been previously filled with dried fine sand **14**. It was then made sure that there was no arching action. Thereafter the slurry **16** containing asbestos prepared as above described was poured and filled into the pipe **13**, as shown in FIG. 3B.

Thereafter, the pipe **13** was gently drawn up out of the fine sand **14**, with the result that there was formed a bore **13'** having a diameter of 100 mm. and a depth of 300 mm. as seen in FIG. 3C and that any breaking of the wall of the bore **13'** was not noted.

EXPERIMENT 3

Slurry containing asbestos and slurry containing bentonite were prepared as stated below, and experiments were made to compare the performances of the two types of stabilization of suspension (all percentages are by weight on the basis of water):

(1) 5% solution of asbestos
(2) 5% solution of asbestos +0.5% of carboxy methyl cellulose (C.M.C.)
(3) 5% solution of bentonite
(4) 5% solution of bentonite +0.5% of C.M.C.
(5) 2% solution of asbestos
(6) 2% solution of asbestos +0.5% of C.M.C.
(7) 2% solution of bentonite
(8) 2% solution of bentonite +0.5% of C.M.C.

For convenience of observation of the inside from the outside, as shown in FIG. 4A, there was provided a glass vessel **17** which has a breadth of 200 mm., a length of 300 mm. and a depth of 300 mm. In the middle of the length, a glass plate **18** was vertically stood to divide the vessel **17** into two compartments.

One of the two compartments defined by the division was filled with fine sand **19** (such sand as used in Experiment 2), while the other compartment was injected only with fresh water **20**, the sand **19** being simultaneously caused to absorb other fresh water sufficiently.

Next, one of the above-mentioned slurry was taken and gradually poured into the one compartment being filled with water **20**. Since the slurry is naturally larger in both the specific gravity and the viscosity than water, the slurry poured was settled in the body of water and hence water **20** overflowed gradually from the upper part of the vessel **17**. As a result, the water having been filled in said one compartment was substituted by the slurry.

Then the partition plate **18** was gently removed (FIG. 4B), and there was examined the soil retaining effect due to the slurry for the sand wall formed.

The above-explained experiment was repeatedly made for the respective slurry having the previously-mentioned different compositions, and the results were as follows:

Stabilization of Suspension	Soil retaining period of time, seconds
(1) 5% of asbestos	15
(2) 5% of asbestos +0.5% of C.M.C.	18
(3) 5% of bentonite	0
(4) 5% of bentonite +0.5% of C.M.C.	7.5
(5) 2% of asbestos	5
(6) 2% of asbestos +0.5% of C.M.C.	7.5
(7) 2% of bentonite	0
(8) 2% of bentonite +0.5% of C.M.C.	0

As is apparently seen from the experiments, the asbestos slurry provides much more excellent soil retaining effects than the bentonite slurry.

EXPERIMENT 4

There will now be described a preliminary experiment carried out at Shizuoka, Japan, which was made to judge whether or not the method of construction work according to the present invention is effective for a ground under extremely severe conditions to obtain the water cut-off effect for the excavated trench.

As a result of boring, the experiment was made for a ground having buried soil at G.L. 0 mm. to −1,200 mm., a silty sand stratum at −1,200 mm. to −2,000 mm., a gravel at −2,000 mm. to −8,000 mm. and a clay stratum at −8,000 mm. to −9,000 mm. There was noted on account of the clay layer that was there infiltration water in the gravel layer located above the clay layer.

In the ground there were dug two wells for observation, into which were filled three kinds of slurry respectively using water, bentonite and asbestos. Then some comparison and study were made on the basis of changes in the liquid level relative to time, i.e. the relation of the liquid level versus time for the manners in which the water cut-off films were formed and the performances of said films with the different slurry to be used for the wall of the trench.

The bentonite muddy water and the asbestos slurry used had the following compositions:

(a) Bentonite muddy water:
Bentonite—10% (by weight on the basis of water)
C.M.C.—0.2% (the same as above)
Viscosity increasing agent (humic acid soda)—0.2% (the same as above)

(b) Asbestos liquid stabilizer:
Asbestos—1.0% (by weight on the basis of water)
Bentonite—6% (the same as above)
C.M.C.—0.1% (the same as above)

In the above-mentioned ground there were driven a steel pipe of 300 ϕmm. down to a depth of 8,000 mm. and that of 100 ϕmm. to a depth of 9,000 mm., each of said pipes being formed with a plurality of slits 240 mm. long and 2.5 mm. width in the length-wise direction on the peripheral surface.

These wells for observation consisting of the steel pipes were filled with water, and measurements were made for the lapse of time by which the water level in the wells were lowered down to the tranquil liquid surfaces.

As a result, when the asbestos slurry was used, it was confirmed after drawing up the 100 ϕmm. and 300 ϕmm. pipes with slits of the wells for observation that water cut-off films were formed and also that the excavated walls were kept in stable states. More particularly, no loss in mud occurred and it was noted by the drawing-up of the pipes that the asbestos was not plugged to the pipes with slits, from which it was confirmed that the slurry acted to form water cut-off films on the walls.

In the analysis of this experimental result, when there is used a bentonite slurry prepared by mixing bentonite into water or an asbestos slurry prepared by incorporating asbestos into water, water flowing in gravel at a velocity of 10^{-3} cm./sec. will become more difficult to flow. Even in the same ground, the flow velocity will become 10^{-4} cm./sec. with the bentonite slurry and 10^{-6} cm./sec. with the asbestos slurry.

Thus, the asbestos slurry has been proved to be far superior in the water cut-off effect to the bentonite slurry.

As a consequence of the above-described preliminary experiment, it was decided to start an excavation for a body of underground continuous wall in the above-mentioned ground. Then, machines for excavation were brought to the building site, and the following test excavation was made:

The channel used for testing the excavation had the dimensions of 60 cm. of width and 4 m. of length. As the excavation proceeded, there were frequently discharged larger gravels than expected, those of 300 mmφ for example. The state of the channel walls was measured with an apparatus employing ultrasonic wave, and no occurrence of breaking was noticed during excavation, immediately after excavation, and after leaving the channel as it was for 5 hours after excavation.

This comes exclusively from the excellent water cut-off property of the slurry using asbestos and from the fact that the asbestos film formed of said slurry exhibits a very large strength, and such is never accomplished with the conventional bentonite slurry.

EXPERIMENT 5

In order to increase the swelling property of asbestos, rotational stirring was carried out with a highly efficient mixer having high revolution and the extent of ability of holding granular particles or solid grains (for example, fine sand) was compared with parameters of the settling quantity of the solid grains and time.

As a result, it was revealed that the ability of holding the sand constituent in the suspension thus diffused and suspended with asbestos makes higher the apparent density of the slurry. For example, a suspension containing 1% of asbestos and 0.5% of C.M.C. has a density of 1.065 g./cc., which is equal to the density of a suspension having the bentonite concentration of 12 to 13%. Accordingly, in spite of the asbestos concentration being as low as 1%, the suspension provided by the swelling of asbestos may have its density optionally chosen to some extent.

The fact that the distribution of asbestos in water can be optionally varied by varying the speed of rotation of the mixer, was assured by the following experiment:

In the respective graduated cylinders **21**, **22**, **23** and **24** of FIGS. 5A, 5B, 5C and 5D each having a depth of 300 mm. and an inner diameter of 70 mmφ, there was kept an asbestos slurry agitated with a mixer at respectively different numbers of rotation per minute. The asbestos slurry was prepared with 0.5% of asbestos and 0.01% of surface active agent.

After about 30 minutes the asbestos slurry in each of the graduated cylinders **21**, **22**, **23** and **24** was separated into asbestos layers **25** and a water layer **26** corresponding to the differences in the number of rotation of the mixer, as shown in FIGS. 5A, 5B, 5C and 5D respectively. More particularly, the asbestos layers **25** were provided between the liquid surface and a level of about 30 mm. therebelow and between the bottom and a level of 45 mm. thereabove at 800 r.p.m. in the number of rotation of the mixer (FIG. 5A), between the liquid surface and a level of 25 mm. therebelow and between the bottom and a level of 90 mm. thereabove at 2,800 r.p.m. (FIG. 5B), between the liquid surface and a level of 130 mm. therebelow and between the bottom and a level of 75 mm thereabove at 6,000 r.p.m. (FIG. 5C), and between the liquid surface and a level of 90 mm. therebelow and between the bottom and a level of 150 mm. thereabove (FIG. 5D) at 12,000 r.p.m.

It is accordingly possible to more accurately supply asbestos through variation in the number of rotation per minute of the mixer to a layer having a large coefficient of permeability such as gravel than to one being small in said coefficient such as clay, the layers being located in a ground.

The inventors have applied this to an execution at a field and have achieved success. Description will now be given of that. Into a hole being 1 m. in diameter and 8 m. in depth and bored for foundation in a building site, Azabu, Tokyo, Japan, there was poured an asbestos liquid stabilizer containing 1% of asbestos which was then agitated by a mixer at 500 r.p.m.

In the liquid was placed an ultrasonic wave generating trembler to measure reflected waves from the channel walls. The reflected waves were severely attenuated from near a depth of 5 m., and reception was made impossible.

The ground of the construction site is outlined to consist of a clay layer down to about 5 m. from the surface of the earth and a sand layer down to the bottom of 8 m. below the clay layer. More particularly, the layer down to 5 m. has a small coefficient of permeability, and hence no loss in water occurred. But the layer between 5 m. to 8 m. is large in the coefficient of permeability on account of its being a sandlayer and it undergoes the generation of permeation, which is believed to have made the reception impossible.

In addition, the number of rotation per minute of the mixer was made a small value of 500 r.p.m., asbestos incorporated into water was easy to settle down and was collected at the lower part of the channel, which is believed to have been one cause of impossibility of obtaining ultrasonic receiving waves below the depth of 5 m.

What is claimed is:

1. A method for stabilizing an excavated trench by filling said trench with a liquid slurry consisting of asbestos fibers suspended in water whereby said liquid slurry will tend to fill any liquid permeable void in the trench wall.

2. The method of claim **1**, wherein said liquid slurry is rotationally mixed to form areas of concentration of the asbestos suspension in the trench.

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U.S. Cl. X.R

166—292